UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 9
75 Hawthorne Street
San Francisco, CA 94105-3901

June 4, 2018

Catherine Jerrard
Program Manager/BEC
AFCEC/CIBW
706 Hangar Road
Rome, New York 13441

RE: Review of the Final Pilot Study Implementation Work Plan for Operable Unit 2, Revised Groundwater Remedy, Site ST012, April 2018

Dear Ms. Jerrard:

EPA has conducted a technical review of the Final Pilot Study Implementation Work Plan for Operable Unit 2, Revised Groundwater Remedy, Site ST012, Former Williams Air Force Base, Mesa, Arizona (the Pilot Study WP), dated April 5, 2018. The Pilot Study WP represents the proposed final revision of the Addendum #2, Remedial Design and Remedial Action Work Plan for Operable Unit 2. The document was renamed as a Pilot Study WP as an outcome of informal dispute resolution, acknowledging an agreement requiring a pilot study to demonstrate within three years that Enhanced Bioremediation (EBR) can effectively remediate the remaining contaminants at the site to achieve the remedial action objectives (RAOs) within the 20-year timeframe specified in the 2013 Amendment to the Record of Decision.

The Pilot Study WP as proposed represents the first phase of a phased implementation of EBR, focusing on the initial injection phase. The Pilot Study WP allows for subsequent phase injection strategies to be developed during the Pilot Study, to be documented in report addenda or field variance memoranda, as noted in Section 3.2.2 (Phased TEA Batch Injections).

However, it is not clear that the agreements reached from the dispute resolution are fully captured and addressed in the Pilot Study WP. The Pilot Study WP states *"The Air Force will complete a Pilot Study Implementation Report within 36 months of the initial pilot study injections to evaluate EBR's primary goal (i.e., achieving groundwater cleanup levels in an estimated 20-year remedial timeframe specified in the 2013 RODA). The metrics and content of this Report will be developed during EBR with the goal of having an agreed upon framework amongst the BCT to evaluate EBR's primary goal."* It is not clear from this text if this Pilot Study Implementation report will be prepared by AF staff, the contractor performing the EBR injections, or a subsequent contractor, or how the efficacy of EBR will be evaluated. If preparation of the Pilot Study Implementation Report will be completed by a third party, it will be that much more critical that the objectives and decision logic for the Pilot Study be clearly specified in the Pilot Study WP.

Contingency Remedies

The dispute resolution stipulated that additional contingency remedies would be required if the three-year Pilot Study failed to demonstrate the ability of EBR to attain RAOs by 2033. The work plan does not specifically cover development of contingency remedies for consideration, as required by the dispute resolution agreement.

Plume Migration

As discussed during the May 17, 2018 BCT call, it is evident that we do not have a clear conceptual understanding of the hydrodynamics of the LNAPL and dissolved phase plume at ST12 Fuel Spill Site, now under high temperature as well as under a rising water table.

With the implementation of sulfate injection proceeding, a significant concern for EPA is preventing the offsite migration of contaminants and avoiding a down gradient groundwater plume directly in the path of the City of Mesa's new drinking water wells. We believe, as AFs modeling figures in the Pilot Study WP suggests, that the proposed injections will most likely increase the mobility of contaminants in the future. Although AF maintains that perimeter monitoring wells still suggest plume stability, EPA remains concerned that AF has not developed specific plans for plume containment nor established monitoring criteria to trigger contingency plans for plume containment. Without a formalized plan in place for plume containment, after the current contract expires there could be a substantial contractual delay preventing AF from responding to plume expansion in a timely manner. *Therefore, EPA maintains the environmental indicator status for ST12 as "groundwater migration not under control", because there are no formal plans in place to prevent migration of contaminants.*

Additional Concerns

Substantial comments remain on the workplan. In general, the remaining concerns fall into the following categories, as summarized below:

A. The planned injections of sulfate as a terminal electron acceptor (TEA) have the potential to worsen ground water conditions at the site by:

   1) displacing LNAPL and dissolved phase contaminants causing them to migrate and spread.

   2) greatly increasing the Total Dissolved Solids (TDS) and sulfate concentrations on site and down-gradient.

   3) increasing arsenic concentrations above drinking water maximum contaminant levels (MCLs).

   4) generating hydrogen sulfide gas and potentially hazardous conditions for which the work plan provides no mitigation plan for response beyond adjusting the injection rate.

B. The planned injections may not provide the needed benefits at the site due to:

1) the extremely large mass of LNAPL and benzene estimated to remain in the subsurface, and the 100-200 year timeframe previously estimated to achieve RAOs via biodegradation.

2) the presence of an LNAPL smear zone across three hydrogeologic units spanning an 80-foot zone of saturation, which will likely hinder the dispersal of sulfate.

3) biofouling of wells impeding distribution of sulfate.

4) injections of sulfate at high concentrations may suppress the microbial populations intended to be enhanced.

5) inadequate demonstration that sulfate depletion and useful rates of biodegradation are currently occurring at the site in areas that already have optimum naturally-occurring sulfate concentrations.

6) it has not been demonstrated that the necessary microbial populations to be enhanced are currently present at the site after it has been heated to boiling temperatures.

C. The monitoring program as proposed in the Pilot Study WP may not provide the necessary data to substantiate any conclusions due to:

1) inadequate baseline data on microbial populations, LNAPL and dissolved phase contaminants of concern (COCs), TDS, sulfate, arsenic for comparison to be able to evaluate progress or changing conditions over time.

2) inadequate and insufficient monitoring network in terms of sampling locations within the treatment zones, and sampling frequency to detect and interpret changing parameters over time.

3) incomplete, vague and ambiguous decision criteria.

4) unverified and unvalidated modeling and assumptions that were admittedly not intended to be used for predictive purposes.

5) lack of clarity in how of achievement of RAOs within 20-year time frame will be demonstrated.

There also remain substantial comments specifically relating to design, operational, sampling and quality assurance issues. We are very concerned that as there are no formalized plans for plume containment, the intentions and objectives of the proposed sulfate injection remain ambiguous. It is not clear from the Work Plan if AF intends to allow contaminants to migrate off site.

Our detailed comments discussing the items summarized above are included in the attached memoranda prepared by EPA's National Risk Management Research Lab as well as EPA's contractor, Techlaw. Although AF has declared this to be a final document, we find the Pilot Study WP insufficiently detailed to implement in its current form.

If you have any questions regarding these comments, please contact me at (415) 972-3150.

Sincerely,

Carolyn d'Almeida

Carolyn d'Almeida
Remedial Project Manager

REFERENCES:

Performance Monitoring of MNA Remedies for VOCs in Ground Water EPA/600/R-04/027, National Risk Management Research Laboratory Office Of Research And Development U.S. Environmental Protection Agency, Ada OK, 2004

Suthersan, et.al. *Engineered Anaerobic Bio-Oxidation Systems for Petroleum Hydrocarbon Residual Source Zones with Soluble Sulfate Application,* Ground Water Monitoring & Remediation 31, no. 3/ Summer 2011

Monitoring the Impacts and Effectiveness of Electrical Resistance Heating with Enhanced Bioremediation Microbial Insights Webinar presentation: https://www.microbe.com/webinars/

cc: Wayne Miller, ADEQ
Phil Mook, AF
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May 17, 2018

OFFICE OF
RESEARCH AND DEVELOPMENT

MEMORANDUM

SUBJECT: Final Pilot Study Implementation Work Plan for Operable Unit 2, Revised Groundwater Remedy, Site ST012, Former Williams Air Force Base, Mesa, Arizona (18-R09-005)

FROM: Eva L. Davis, PhD, Hydrologist

TO: Carolyn d'Almeida, Remedial Project Manager, Region 9

I have reviewed the Final Pilot Study Implementation Work Plan for Operable Unit 2, Revised Groundwater Remedy for Site ST012 at the Former Williams Air Force Base, located in Mesa, Arizona. The work plan has undergone some revisions since it was first submitted as Draft Addendum #2 to the Remedial Design/Remedial Action Work Plan (RD/RAWP) in November 2015, however, many of the comments submitted on the original document and its revisions still have not been adequately addressed. Due to the fact that this version of the work plan is being implemented, my comments focus on the implementation plans that are presented. My comments are provided in detail below.

General Comments

1.The proposed approach for the pilot EBR is not consistent with recommended practices found in the research literature. In fact, the literature recommends against large influxes of sulfate concentrations, as proposed here, which can cause sulfide production, total dissolved solids (TDS) increases, and gypsum production, which have the potential to stress the microbial community, inhibiting microbial activity and/or the ability to continue injecting the sulfate (Suthersan, Houston, Schnobrich, and Horst, Engineered Anaerobic Bio-Oxidation Systems for Petroleum Hydrocarbon Residual Source Zones with Soluble Sulfate Application, Ground Water Monitoring & Remediation, 31(3):41-46, 2011). Suthersan et al. go on to say, "a reasonable level of control on sulfate dosing can help manage most of these potential complications . . . sulfate application strategies that employ repeat injections at highly elevated concentrations may not be as effective as sulfate delivery strategies that achieve relatively steady sulfate concentrations over time in the range of 100 to 2000 mg/L". ESTCP (Enhanced in situ Anaerobic Bioremediation of Fuel-Contaminated Ground Water, US Department of Defense, CU-9522, 1999) states, "a practical limit for nitrate or sulfate introduction is around 80 mg/L. . . sulfate introduction is based on the fact that sulfate reduction can result in the accumulation of sulfide, which is inhibitory to many biodegradation processes." The proposed injections at 160,000 to 320,000 mg/L – two orders of magnitude greater concentration than recommended for optimal microbial growth – has the potential to make the groundwater quality worse without providing any significant benefit.

The ways in which these injections can make the situation worse includes: a) displacement of mobile LNAPL and dissolved phase contaminates into areas that were not previously impacted through the injection of very large quantities of sulfate-spiked water; b) introduction of sulfate into the subsurface at concentrations that exceed the Federal Drinking Water Guideline of 250 mg/L by as much as three orders of magnitude; c) by the introduction of a significant quantity of arsenic to the subsurface. Each of these is discussed in more detail below.

a) Many of the planned injection/extraction well pairs call for extraction at the downgradient extent of the plume, allowing for LNAPL and dissolved phase contamination to be pushed downgradient. Examples of this are in injection/extraction well pairs CZ10/CZ07; CZ12, CZ03, & CZ16/CZ21; UWBZ10/UWBZ28; UWBZ12/UWBZ21; UWBZ16, 23, 29/UWBZ30; LSZ08 & LSZ17/LSZ51.
b) Background concentrations of sulfate, which are generally around 300 mg/L, already exceed the Federal Drinking Water Guideline of 250 mg/L. Figures F-4 to F-9 clearly show sulfate concentrations 10,000 to 1,000 mg/L in excess of background concentrations leaving the contaminated area of the cobble zone (CZ) and migrating downgradient beginning within 120 days of the injections, and continuing for more than three years. About one year after injections, sulfate concentrations 1,000 to 10,000 mg/L in excess of background concentrations will begin migrating out of the contaminated zone in the UWBZ, and this will continue for far more than the six years for which model results are presented. In the LSZ, sulfate concentrations 1,000 mg/L in excess of background concentrations leave the contaminated area for more than six years after injection.
c) Arsenic is an impurity in sodium sulfate. According to Section 3.3, certificates of analysis for the planned source of sodium sulfate showed non detect for arsenic in the past, with detection limits between 0.308 and 0.568 mg/kg. According to Amec's calculations in Appendix H, arsenic concentrations in the injectate are expected to range from 300 to 960 µg/L – approaching two orders of magnitude greater concentration than its Federal Drinking Water Maximum Contaminant Level (MCL) of 10 µg/L. The total mass of arsenic they expect to inject is enough to contaminate more than 60 million gallons of groundwater. Arsenic will clearly migrate downgradient from the treatment area along with the sulfate.

Despite the fact that the modeling performed clearly predicts that excessive sulfate concentrations will migrate off site, the re-circulation system that was included in the May 2014 RD/RAWP is not included in the Pilot Study Work Plan. Currently the monitoring plan in

Section 5 of the Pilot Study Work Plan calls for sampling the perimeter wells for VOCs, sulfate, and metals every three months. However, baseline data on these compounds is not being collected at all the perimeter wells, and there are no firm criteria in the Decision Matrix on threshold concentrations or concentration increases that would trigger implementation of recirculation when contaminants begin to show up at the perimeter wells. In the case of the CZ, the downgradient migration of sulfate (and thus arsenic) is expected to occur so rapidly that recirculation should be included at startup of injections into the CZ. Also, the extracted water treatment system should include arsenic removal so that arsenic is not re-injected into the aquifer.

2. The June 2016 baseline data shows that sulfate is not depleted in many areas of the jet fuel contaminated aquifer. This is especially true in the CZ, where sulfate concentrations range from 130 to 320 mg/l, in wells with benzene concentrations of 87 to 1200 ug/l, indicating the lack of sulfate consumption is not due to a lack of carbon substrate. ESTCP (1999) states, "Benzene, the most toxic of the BTEX compounds, has not been conclusively shown to degrade under all anaerobic conditions that exist in the field." Degradation that is not already occurring cannot be enhanced by the addition of large quantities of sulfate. Currently there is no data to demonstrate that sulfate degradation is occurring in the CZ.

3. Section 3.2.2 states, "test results (EBR monitoring data) including ongoing collection of LNAPL from completed wells would be used to evaluate if additional wells are needed to further characterize the limits of LNAPL". What monitoring results will trigger additional characterization activities? Please explain how it is believed that EBR can potentially be completed to return the aquifer to drinking water standards without defining the extent of LNAPL, and thus without addressing the full extent of LNAPL.

Specific Comments

4. Section 3.3 on page 3-7 states, "Individual areas of well influence were determined using Theissen polygons fitted to the injection locations . . .". However, the groundwater modeling results in Appendix F clearly indicate that water injected into SVE04 will not flow to extraction well CZ18; injections into CZ10, CZ11, and CZ12 will not flow to extraction well CZ21; injection into UWBZ32 will not flow to extraction well UWBZ22; injection into LSZ44 and W34 will not flow to extraction well LSZ29; injection into LSZ45, LSZ46, and W37 will not flow to extraction well LSZ12, as shown in the figures on slides 23, 24, and 25, respectively, of the April 17, 2018 BCT meeting.

5. Section 3.3 on page 3-8 states, "Baseline sampling conducted in July 2016 detected arsenic concentrations up to 110 μg/L although arsenic was not detected at most perimeter location. . . . There is no indication arsenic is migrating downgradient." These statements are misleading for more than one reason. First, according to the 2016 baseline sampling results contained in the Soil Vapor Extraction/Steam Enhanced Extraction System Operation and Maintenance Third Quarter 2016 Performance Report, four wells had arsenic concentrations greater than 110 μg/L: UWBZ30 and LSZ51 are both reported at 15 mg/L, UWBZ35 is reported at 7.3 mg/L, and

UWBZ29 is reported at 0.13 mg/L. Second, most of the downgradient sentry wells were not tested for arsenic, thus there is no way of knowing if arsenic is migrating offsite currently. What is obvious from the figures in Appendix F is that arsenic will migrate off site if injected into downgradient injection wells CZ10, CZ11, CZ12, UWBZ10, UWBZ12, UWBZ32, LSZ36, LSZ44, LSZ45, LSZ46, LSZ47, W34, and W37, as planned.

6. Figures 3-2, 3-3, and 3-4 show that the majority of the wells that are to be used as monitoring wells are not located properly to monitor EBR, as they are not located in between the injection and extraction wells.

7. Figure 3-4 shows that well W-34 is to be used for injection. By making well W34, which is currently a perimeter well, an injection well, there will then be no perimeter well in this vicinity to observe the downgradient migration. Either this well should not be used for injection or a downgradient perimeter well must be installed.

8. Section 4.2.6 discusses contingency planning, but makes no commitments to address the potential problems that may be encountered during the pilot scale EBR implementation. Instead of presenting a conditions that will trigger action to address problems that are identified by monitoring, the contingency plan only states actions that 'will be considered'. Monitoring data must be acted on to correct the observed problems in order for the monitoring to be useful. In consultation with the Agencies, threshold criteria should be established for each possible problem and remedies identified that will be triggered by threshold observations.

9. The groundwater head model results shown in Figures F-5, F-31, and F-51 do not represent groundwater heads or gradients provided in the Health, Safety, Environment and Remediation Site Operations Report for ST012.

10. Figures F-21 to F-30 clearly show that an area of known LNAPL contamination exits in the LSZ at SB-19, upgradient of the EBR treatment area. It is currently not known how far upgradient this source zone extends. Please explain how it is believed that EBR can potentially be completed without addressing all of the known LNAPL.

11. The Decision Matrix in Appendix J in the box, Target Criteria to Optimize Biological Degradation by SRB at ST012, presents average and maximum benzene concentration targets for each of the three vertical treatment zone that are based on the modeling contained in Appendix E of the RD/RAWP. Previous discussions on this model revealed that this was not a predictive model. These target concentrations cannot be relied on to trigger transitioning from EBR to MNA.

12. The Decision Matrix in Appendix J in the boxes, To Establish Biological Degradation by Sulfate Reducing Bacteria (SRB) at ST012 and has been Enhanced, Target Criteria to Optimize Biological Degradation by SRB at ST012, and Transition Criteria Achieved?, present average and maximum sulfate concentration targets of 2,000 – 10,000 mg/L and 30,000 mg/L,

respectively. These target concentrations far exceed the optimum range of 100 to 2000 mg/L presented by Suthersan et al. (2011). Please see comment #1.

If you would like to discuss any of these comments, I would be happy to do so. I can be reached at (580) 436-8548 or davis.eva@epa.gov.

cc: Anna-Marie Cook, Region 9
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April 25, 2018

Ms. Carolyn d'Almeida
U.S. EPA, Region IX
75 Hawthorne Street, SFD-8-1
San Francisco, California 94105

Subject: Contract No. EP-W-07-066, Task Order No 066-016-09Q1, Williams Air Force Base Task Order, Review of the Final Pilot Study Implementation Work Plan for Operable Unit 2, Revised Groundwater Remedy, Site ST012, Former Williams Air Force Base, Mesa, Arizona, April 2018

Dear Ms. d'Almeida:

TechLaw conducted a technical review of the Final Pilot Study Implementation Work Plan for Operable Unit 2, Revised Groundwater Remedy, Site ST012, Former Williams Air Force Base, Mesa, Arizona (the Pilot Study WP), dated April 5, 2018.

The Pilot Study WP only focuses on the initial injection phase. Subsequent phase injections strategies will be developed during enhanced bioremediation (EBR) monitoring periods and will be documented in report addenda or field variance memoranda, as noted in Section 3.2.2 (Phased TEA Batch Injections).

TechLaw did not review or provide comments on Appendices E (TestAmerica Analytical Reports) or K (Response to EPA and ADEQ Comments). Based on a cursory review of Appendix K, TechLaw determined that many of the issues previously commented on remained despite the initial response provided. As a result, TechLaw provided new comments on the issues previously commented on to ensure prescriptive responses are provided.

The comments are forwarded to you in Word format. TechLaw understands you will review and revise these comments at your discretion.

We appreciate the opportunity to provide technical support services to U.S. EPA on this Task Order. Should you have any questions or comments, please contact me or the TechLaw Project Manager, Nicole Goers, at (540) 836-0420.
Sincerely,

Indira B. Balkissoon

Indira Balkissoon
ROC 9 Senior Task Order Manager

NG/NT:KB/DD:IB:as

cc: Central files, TechLaw, Inc.

FORMER WILLIAMS AIR FORCE BASE
Mesa, Arizona

Review of the Final Pilot Study Implementation Work Plan for Operable Unit 2, Revised Groundwater Remedy, Site ST012, April 2018

Submitted to:

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Task Order No.	**066-016-09Q1**
Contract No.	**EP-W-07-066**
EPA TOCOR	**Carolyn d'Almeida**
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April 25, 2018

Review of the Final Pilot Study Implementation Work Plan for Operable Unit 2, Revised Groundwater Remedy, Site ST012, April 2018

GENERAL COMMENTS

1. Insufficient decision criteria is provided in the Final Pilot Study Implementation Work Plan for Operable Unit 2, Revised Groundwater Remedy, Site ST012, Former Williams Air Force Base, Mesa, Arizona, dated April 5, 2018 (the Pilot Study WP). For example,

- **a.** Section 2.3 (Pre-EBR COC Extent Estimate) states, "Given the required assumptions to make these estimates, it is recognized that actual COC [contaminant of concern] mass may be different and EBR [enhanced bioremediation] approaches may require adjustment as the project progresses;" however, Appendix J (Operational Decision Matrix) does not include decision criteria associated with mass.
- **b.** Section 2.4 (Review of Previous EBR Pilot Test Results) indicates that the EBR field test hydraulic parameter testing showed that any future use of existing monitoring wells for terminal electron acceptors (TEA) injection locations should only be considered after redevelopment; however, Appendix J does not include decision criteria associated with the use of existing monitoring wells for TEA injection locations or recommend redevelopment of monitoring wells.
- **c.** Section 3.2.1 (Groundwater Extraction and Treatment) indicates that "Groundwater will be extracted from 20 extraction wells either controlled using water level transmitters that serve as inputs to local variable frequency drives (VFDs) that adjust the speed and flow rate of the extraction pumps to control water level or controlled using pneumatic pumps that control water level in the well by the elevation of their water intake;" however, the decision criteria that will be used to determine how the extraction wells are controlled are not specified.
- **d.** Section 3.2.2 (Phased TEA Batch Injections) states, "Updates to the groundwater model will be incorporated in subsequent phases as appropriate when additional data is available;" however, Appendix J does not discuss updates to the groundwater model or the decision criteria that will be utilized to determine sufficient additional data is available to update the groundwater model. Similarly, QAPP Worksheet #11 (Project Quality Objectives/Systematic Planning Process Statements) of Appendix I (QAPP/SAP Worksheets) indicates that the groundwater model will be updated based on the hydraulic and biodegradation parameters, as well as trends in BTEX+N [benzene, toluene, ethylbenzene, xylene, and naphthalene] concentrations based [*sic*] on field data to aid in the decision to transition to MNA [monitored natural attenuation]."
- **e.** Section 3.2.2 states, "Specifically, test results (EBR monitoring data) including ongoing collection of LNAPL [light nonaqueous phase liquid] from completed wells would be used to evaluate if additional wells are needed to further characterize the limits of LNAPL. Any additional investigation would occur in a subsequent phase of EBR implementation;" however, Appendix J does not include additional wells to further characterize the limits of LNAPL as a potential contingency.
- **f.** Section 3.2.3 (TEA Recirculation) indicates that it may become necessary to implement a recirculation strategy to increase TEA distribution in specific areas of

the site subsurface; however, the specific decision criteria that would trigger this evaluation are not provided in Appendix J. Based on Appendix J, if limited sulfate distribution is observed, recirculation will be implemented to improve sulfate distribution. Yet, quantitative decision criteria associated with sulfate distribution is not provided.

g. Based on Appendix J, if sulfate shows up at extraction wells earlier or later than expected, extraction/injection rates or future injection concentrations will be adjusted; however, the specific timeframes that sulfate is expected to show up in each extraction well associated with an injection well are not provided and/or referenced. It should be noted that Section 5.3 (Extraction Well Sampling) states that, "TEA travel times will vary between different injection/extraction well pairs." As a result, it is unclear if the sulfate will show up earlier or later than expected at the extraction wells. This is of particular concern given that Table 5-1 (EBR Monitoring, Sampling, and Analysis Methods and Frequencies) indicates that groundwater/perimeter monitoring wells will only be sampled quarterly. As a result, it is unclear if sufficient monitoring is proposed to evaluate TEA distribution between and crossgradient from the injection and extraction wells. It is unclear why the EBR design does not include the use of a tracer in each injection well injection which can be sampled for on a weekly basis at the monitoring wells located between and crossgradient from the injection and extractions wells pairs. The use of a tracer would provide a more accurate timeframe to indicate when sulfate is expected to show up in each extraction well associated with an injection well to ensure timely adjustments are made to the EBR design. Similarly, the use of a different tracer in each injection well when several injection wells are serviced by one extraction well would provide valuable information regarding the effectiveness of the injection and extraction well pairs.

h. Section 4.1.2 (Installation of Extraction and Injection Wells) indicates that following well development, well pumps and packers will be installed where necessary; however, the decision criteria that will be used to determine where wells pumps and packers will be installed is not provided and/or referenced.

i. Section 5.4 (Groundwater Monitoring Well Sampling) states, "Bio-trap® samplers from Microbial Insights, seeded with synthesized forms of benzene and naphthalene containing carbon isotope ^{13}C, will be placed in each well for approximately one month;" however, the decision criteria used to determine the location of the Bio-trap® samplers within each well are not provided and/or referenced.

j. Appendix J includes several desired trends such as "consistent with expectation," "Decreasing," "Depleted," "Stable or slowly changing" or "Increased" yet specific decision criteria associated with these desired trends are not provided and/or referenced. For example, decreasing VOCs are a desired trend yet it is unclear if these are decreasing VOCs as compared to baseline conditions or a Mann-Kendall analysis.

k. Appendix J does not include decision criteria for monitoring changed conditions.

Please revise the Pilot Study WP to include sufficient decision criteria to support the dynamic approach proposed for implementation.

2. Insufficient information is provided to support the extent of treatment proposed in the Pilot Study WP and the COC mass remaining at ST012. According to Section 2.3 (Pre-EBR COC Extent Estimate), "The remaining COC mass at ST012 was estimated using the updated pre-SEE [steam enhanced extraction] LNAPL volume estimate (i.e., pre-SEE LNAPL Extent Interpretation Update) described in Section 2.1 as the baseline and applying a theoretical extent of treatment based on observed mass recoveries during SEE operations." This theoretical extent of treatment, as described in Section 2.3, included applying an assumed removal percentage based on distance from the thermal treatment zone (TTZ). For example, a zone of treatment [Thermal Influence Zone (TIZ)] was estimated 10 meters outside the TTZ where treatment "was not expected to be as effective because temperatures in this zone were elevated but did not reach steam temperatures as within the TTZ, so removal was initially estimated at 60%." However, information to support the extent of the TTZ, the use of 10 meters beyond the TTZ for the TIZ, and the use of 60% for the TIZ is not provided and/or referenced. Given that the assumed COC mass remaining at the site is based on a theoretical extent of treatment, it is unclear if the EBR design is appropriately targeting COC mass. Please revise the Pilot Study WP to provide quantitative information to support the use of an assumed removal percentage based on distance from the TTZ as it is critical to supporting the extent of treatment proposed in the Pilot Study WP and the COC mass remaining at ST012.

3. Information to substantiate the use of mass calculations based on residual saturation at lower temperatures and that the mobile LNAPL is limited in extent compared to residual LNAPL is not provided and/or referenced. According to Section 2.1 (LNAPL Extent Update) states, "The presence of mobile LNAPL during the PDI [Pre-Design Investigation] and the volumes removed during and after SEE operations indicate that there is mobile LNAPL at ST012; however, some of this mobile LNAPL, especially near and inside the former SEE TTZs, is mobile because of reductions in LNAPL viscosity associated with the increased temperatures from SEE. Therefore, mass calculations based on residual saturation at lower temperatures are appropriate to estimate residual LNAPL mass. In addition, it is expected that mobile LNAPL at ST012 is limited in extent compared to residual LNAPL;" however, information to substantiate the use of mass calculations based on residual saturation at lower temperatures is not provided and/or referenced. Further, information to substantiate that mobile LNAPL is limited in extent as compared to residual LNAPL is not provided and/or referenced. It should be noted that Table 2-4 temperature monitoring point (TMP) Temperature Readings for January 2018) indicates that temperatures at ST012 remain elevated, further calling into question the use of mass calculations based on residual saturation at lower temperatures. Please revise the Pilot Study WP to provide information to substantiate the use of mass calculations based on residual saturation at lower temperatures given current and anticipated site conditions. In addition, please revise the Pilot Study WP to provide information to substantiate that the mobile LNAPL is limited in extent as compared to residual LNAPL.

4. According to Section 2.2.3 (LNAPL at ST012 Wells), the observed LNAPL accumulations presented in Appendix C (Post-SEE LNAPL Gauging and Removal Log) identify well locations of interest for TEA injections; however, LNAPL measurement records are only provided from the end of SEE through 26 May 2017 in Appendix C. Given that LNAPL measurements were last taken on 4 April 2018, it is unclear if the well locations of interest for TEA injections presented in the Pilot Study WP remain appropriate. Please revise the Pilot Study WP to present updated LNAPL accumulations and ensure that the well locations of interest for TEA injections are based on the updated LNAPL accumulations.

5. Outdated information is presented throughout the Pilot Study WP. As a result, it is unclear if the EBR design remains relevant. For example,

- **a.** Section 2.2.3 (LNAPL at ST012 Wells) states, "Starting on 23 December 2014, ST012-W37 developed a measureable layer of LNAPL. Since that time, LNAPL has been removed on a regular basis from the well. Starting on 23 January 2015, ST012-W11 also began to accumulate a measurable LNAPL layer. ST012-W30 also began to periodically accumulate a measureable LNAPL layer starting on 09 June 2015. All three of these well locations historically had measureable LNAPL prior to SEE. The SEE activities resulted in enhanced mobility of LNAPL in the vicinity of these wells resulting in increased accumulation in the wells;" however, information to substantiate that the accumulation in these wells is due to enhanced mobility of LNAPL due to SEE is not provided and/or referenced. Specifically, pre- and post-SEE accumulation levels are not provided in the Pilot Study WP. It should be noted that LNAPL thicknesses are only provided from 29 April 2016 to 26 May 2017 for ST012-W11 and ST012-37 in Appendix C (Post-SEE LNAPL Gauging and Removal Log). Given the uncertainty associated with the LNAPL accumulations found at ST012-W11, ST012-30, and ST012-W37, it is unclear if these wells are appropriate for TEA injection, as proposed on Figure F-15 (Modeled TEA Injection Pathlines, Lower Saturated Zone, 220 ft bgs). Pre- and post-SEE accumulation levels to support the conclusion that the LNAPL accumulations found at ST012-W11, ST012-30, and ST012-W37 are associated with the enhanced mobility of LNAPL due to SEE are needed.
- **b.** Section 2.2.2 (Groundwater Concentrations) indicates that Table 2-3 [BTEX+N Groundwater Concentrations during SEE (September 2014 through April 2017)] presents the most recent available groundwater monitoring data at each location that has been sampled; however, Table 2-3 only presents groundwater concentrations through April 2017. As a result, it is unclear if the dissolved contaminant of concern (COC) concentrations remain unchanged at perimeter well locations that are of interest for TEA injections.
- **c.** According to Section 2.4 (Review of Previous EBR Pilot Test Results), the EBR field test was conducted prior to SEE at ST012-W11 and ST-12-W30; however, it is unclear if the EBR field test results remain relevant following SEE as no post-SEE EBR field test was conducted. This is of particular note given the potential for temperature to impact the sulfate-reducing bacterial (SRB) populations. In addition, the EBR field test did not include the Cobble Zone (CZ), which was recently re-saturated as the water table has risen. As such, it is unclear if the SRB populations are present in the CZ or have been impacted by the SEE.

d. Based on Section 2.6 (Groundwater Model Sulfate Distribution Tracking), the groundwater model is based on hydrostatic conditions at ST012 prior to SEE influence. As such, it is unclear if it remains representative of site conditions and is appropriate for sulfate distribution tracking.

e. Section 3.3 (TEA Dosage) states, "From the groundwater model concentration non-reactive transport figures showing sulfate for each zone in Appendix F, the injected concentration of sulfate reduces by approximately two orders of magnitude in most areas of the site over a period of about five years and reduces by approximately one order of magnitude in the worst-case areas (vicinity of UWBZ [Upper Water Bearing Zone] injection wells) over five years;" however, it is unclear if the groundwater model accounted for off-site groundwater extraction that is likely to change/increase over time.

Please revise the Pilot Study WP to present current information.

6. While groundwater flow at ST012 is predominantly from west to east, the direction of groundwater flow is not included on any Pilot Study WP figures. This is of particular note given the plan to use extraction wells to alter the direction of groundwater flow and distribute TEA. For example, Figure F-15 (Modeled Tea Injection Pathways, Lower Saturated Zone, 220 ft bgs) shows the extraction wells pulling groundwater northwest and southwest at varying angles. Please revise the Pilot Study WP figures to include the direction of groundwater flow.

7. The injection well and associated extraction wells, presented in Table 4-1 (Proposed Injection and Extraction Wells and Screened Intervals), are not clearly defined on Figures 3-2 (EBR Injection, Extraction and Monitoring Well Locations – CZ), 3-3 (EBR Injection, Extraction and Monitoring Well Locations – UWBZ), or 3-4 (EBR Injection, Extraction and Monitoring Well Locations – LSZ). As a result, it is difficult to determine if sufficient groundwater monitoring is proposed between, crossgradient, and downgradient of the injection/extraction well pairs. Please revise the Pilot Study WP to include figures which clearly show the injection/extraction well pairs and groundwater monitoring wells proposed between, crossgradient, and downgradient of the injection/extraction well pairs.

8. Based on Figures 3-2 (EBR Injection, Extraction and Monitoring Well Locations – CZ), 3-3 (EBR Injection, Extraction and Monitoring Well Locations – UWBZ), and 3-4 (EBR Injection, Extraction and Monitoring Well Locations – LSZ), insufficient groundwater monitoring is proposed. For example, no groundwater monitoring wells are proposed downgradient of ST012-CZ21, an extraction well located in the southeast corner of ST012. According to Table 4-1 (Proposed Injection and Extraction Wells and Screened Intervals), ST012-CZ21 is associated with injection wells ST012-CZ11, ST012-CZ12, and ST012-CZ16 and will be operated as part of Manifold 1 and 2. As such, downgradient monitoring wells will be critical to ensure LNAPL and/or COC mass are not displaced offsite. This is of particular note given the TEA injection pathlines presented in Appendix F do not end up at an extraction well. Please revise the Pilot Study WP to include sufficient groundwater monitoring. At a minimum, each injection/extraction well pair should include a groundwater monitoring well between, crossgradient, and downgradient of the injection/extraction well pairs to ensure LNAPL and/or COC mass are not displaced as a result of the EBR design.

9. Based on the LNAPL Monitoring/Removal Status figures presented in the April 2018 Base Realignment and Closure (BRAC) Cleanup Team (BCT) Meeting presentation, LNAPL was detected in several perimeter monitoring wells (e.g., UWBZ09, ST012-W30, LSZ50, ST012-W11, LSZ46); however, additional characterization is not discussed or proposed. According to the LNAPL Encountered subsection of Section 4.2.6 (Conceptual EBR Contingency Planning), "If the LNAPL is discovered in an area along the perimeter of the site, further characterization will be evaluated in the form of additional soil borings as part of a future phase." Please revise the Pilot Study WP to include additional soil characterization at these locations prior to implementation of the EBR design.

10. Based on the Limited Sulfate Distribution subsection of Section 4.2.6 (Conceptual EBR Contingency Planning), if sulfate is not detected at expected concentrations in monitoring or extraction wells after the approximate travel time estimated by the groundwater model, then "Actual groundwater elevations and pumping rates measured during the injections will be input into the groundwater model to evaluate if there is an explanation for the increased travel time or unexpected subsurface sulfate distribution." However, it is unclear why the groundwater model would not be updated regardless of whether sulfate is not detected at expected concentrations in monitoring or extraction wells after the approximate travel time estimated by the groundwater model. This is of particular note given the proposed use of the groundwater model for subsequent phases of the EBR design. Please revise the Pilot Study WP to clarify why the groundwater model would not be updated regardless of whether sulfate is not detected at expected concentrations in monitoring or extraction wells after the approximate travel time estimated by the groundwater model.

11. Insufficient information is provided to support the information presented in Appendix F (Groundwater Model Outputs) as only outputs are provided. For example, the Appendix F figures [e.g., Figure F-1 (Modeled Tea Injection Pathline, Cobble Zone, 160 ft bgs)] includes TEA injection pathlines outside the ST012 site boundary. As such, it is unclear what boundary conditions were utilized in the groundwater model. Without input parameters and boundary conditions, it is unclear how the groundwater modeling can be assessed to ensure TEA distribution based on hydrogeology at the site is achieved with the proposed EBR design. Please revise the Pilot Study WP to include a complete groundwater modeling report including, but not limited to input parameters and boundary conditions utilized.

12. The City of Mesa sewer discharge permit is not included in the Pilot Study WP. Given the need to meet specific sewer discharge permit criteria (e.g., maximum daily discharge flowrate), please revise the Pilot Study WP to include a copy of the City of Mesa sewer discharge permit.

13. Several issues exist related to the EBR system described in Section 3.2.1 (Groundwater Extraction and Treatment) and shown on Figure 3-1 (EBR System Process Flow Diagram). For example,

a. Section 3.2.1 states, "Water pumped by the extraction well pumps will be directed through a tee fitting where a chemical feed pump will inject chemical into the water stream and will pass through a static mixer prior to discharge into an equalization tank" and "After oil-water separation, process water will pass through a tee fitting where a feed pump will inject chemical into the water stream and will pass through a static mixer prior to discharge into the air stripper;" however, the chemicals are not specified or discussed in Section 3.2.1 or Figure 3-1. As such, it is unclear what impact the chemicals will have on the EBR system. For example, if a metal precipitant and/or coagulant/flocculent is utilized, it is unclear if special clean-out procedures will be necessary in the influent equalization tank.

b. Section 3.2.1 indicates that water leaving the equalization tank will pass a temperature transmitter, which will shut down the system if the temperature is too high for subsequent treatment equipment and discharge into the City of Mesa sewer, yet a specific temperature is not provided and/or referenced. Further, it is unclear what circumstances would result in water being discharged to the City of Mesa sewer given that the treated water is intended to be used as make-up water in the injection process.

c. Based on Figure 3-1, the oil-water separator is situated after the influent equalization tank and bag filter in the EBR system process; however LNAPL would impact these EBR system components and result in the requirement for special clean-out procedures. It is recommended that the oil-water separator be located before initial chemical addition, the bag filter, and equalization tank in the EBR system process to remove LNAPL prior to addressing/treating other groundwater/contaminant issues.

Please revise the Pilot Study WP to address these issues associated with the EBR system.

14. The sample analysis information presented in the Quality Assurance Project Plan (QAPP) found in Appendix I (QAPP/SAP Worksheets) is insufficient. Examples of insufficient information are as follows:

a. QAPP Worksheet #12 (Measurement Performance Criteria) indicates that LNAPL samples will be analyzed by Pace; however, project action levels (PALs) for LNAPL samples are not provided. PALs are also not provided for the sodium sulfate composite samples listed in Table 17.1 (EBR Sampling Summary Table).

b. The QAPP does not provide contact information for TestAmerica, Microbial Insights, or Pace, including the names, phone numbers and email addresses of the laboratory project managers or the addresses where samples should be shipped for analysis.

c. The laboratory-specific standard operating procedures (SOPs) for Microbial Insights and Pace are not provided. Without this information, the adequacy of the laboratory methods cannot be evaluated. In addition, the QAPP indicates that several TestAmerica SOPs can be found in the Performance Based Remediation Program

Quality Assurance Project Plan and Standard Operating Procedures, Performance-Based Remediation Task Order, Former Williams Air Force Base, Mesa, Arizona (the Program QAPP). However, the Program QAPP is dated July 2012, and therefore, it is unclear if the TestAmerica SOPs are the most current versions. It is also unclear if any of the analytical SOPs will be modified for this project.

d. SOP SOC-8081 from ALS is included in Attachment B to QAPP Worksheet #30 (Laboratory SOPs: High Resolution Method 8081A and Methods 8081A/8082), but ALS is not identified as a laboratory to be used during this investigation.

e. The type and size of the sample container, minimum sample volume, preservative, and holding time information is not provided for the sodium sulfate composite samples listed in Table 17.1. Additionally, the QAPP does not indicate that water sample containers for volatiles should be filled so that there is no head-space.

f. Table 18.4 (Quarterly Injection Well/Weekly Injection Solution Sampling) in QAPP Worksheet #18 (Sampling Locations and Methods/SOP Requirements Table) indicates that samples will be analyzed for alkalinity by method SM 2320B as part of the quarterly injection well/weekly injection solution sampling. However, alkalinity is not discussed elsewhere in the QAPP for the current investigation.

g. The QAPP references the Program QAPP for analytical instrument calibration, maintenance, testing, and inspection requirements; however, the Program QAPP does not include this information.

h. The analytical quality control (QC) requirements, QC acceptance criteria, and corrective actions have not been specified. As an example, it is unclear if a post-digestion spike (PDS) will be performed when a matrix spike (MS) does not meet acceptance criteria for method 6010B or what the percent recovery acceptance limits of the PDS should be. The Program QAPP indicates that this information can be found in the laboratory SOPs; however, this information should be provided in the QAPP tables (e.g., QAPP Worksheet #28) so it is readily available when evaluating the quality and usability of the data.

Please revise the QAPP to provide all elements required by the *Uniform Federal Policy for Quality Assurance Project Plans Manual*, dated March 2005 (UFP QAPP Manual) for sample analysis.

15. The presentation provided in the Pilot Study WP is incomplete. Specifically, the Pilot Study WP references information provided in several other documents which may not be easily accessible to readers. For example,

a. Section 2.1 (LNAPL Extent Update), "Those borings were also advanced using sonic drilling techniques and are documented in Appendix G of the 2016 Third Quarter Performance Report (Amec Foster Wheeler, 2017a)."

b. Section 2.1 states, "Preliminary boring logs and analytical results for the additional characterization locations were provided to the regulators via the project SharePoint site and during routine meetings and will be documented in detail in the 2016 Annual Performance Report (in preparation)."

c. Section 2.2.2 (Groundwater Concentrations) indicates that, "The total list of results for volatile organic compounds (VOCs) is presented in the ST012 quarterly/annual reports (Amec Foster Wheeler, 2016c; 2016d; 2017a; 2017b; 2017c; 2017d)."
d. Section 2.5 (Background Groundwater Geochemical Analysis) states, "Baseline EBR sampling was conducted in July and August 2016 and included geochemical parameters. This data is presented in the 2016 third quarter operation and maintenance report (Amec Foster Wheeler, 2017a)."
e. The footnote in Table 2-8 (Summary of Updated Model Layers) states, "See the Final Remedial Design and Remedial Action Work Plan for additional model details (AMEC, 2014a)."
f. Section 4.1.2 (Installation of Extraction and Injection Wells) indicates that the drilling subcontractor drilled recent well borings using the sonic drilling technique and that specific installation details and records "will be documented in well drilling reports attached to the quarterly reports."

To ensure a complete presentation is provided, please revise the Pilot Study WP to include pertinent information in appendices.

SPECIFIC COMMENTS

1. **Section 2.1, LNAPL Extent Update, Page 2-2:** The section states, "The volume initially removed from SEE wells may represent LNAPL present in the SEE wells or the well sand pack at the end of SEE rather than LNAPL that migrated to the well after SEE shutdown;" however, information to substantiate that the volume initially removed was LNAPL present in the SEE wells or the well sand pack at the end of SEE rather than LNAPL that migrated to the well after SEE shutdown is not provided and/or referenced. It should be noted that 450 gallons of LNAPL was recovered after the initial removals from former SEE wells inside the TTZ indicating that migration to the well after SEE shutdown is occurring. As such, insufficient information is available to substantiate that the approximately 1,750 gallon of LNAPL initially removed from the SEE wells following SEE shutdown is LNAPL that was present in the SEE wells or the well sand pack at the end of SEE rather than LNAPL that migrated to the well after SEE shutdown. Please revise Section 2.1 to clarify that insufficient information is available to determine if the volume initially removed was LNAPL present in the SEE wells or the well sand pack at the end of SEE rather than LNAPL that migrated to the well after SEE shutdown.

2. **Section 2.2.1, SEE Mass Removal, Page 2-4:** Information to support the correction factor methodology used or to document the photoionization detector (PID) readings before and after use of the correction factor are not provided and/or referenced in the Pilot Study WP. According to Section 2.2.1, a correction factor was applied to the PID readings based on "the most recent analytical data at the time of each reading. The corrected PID mass loading rate for each day was summed to calculate the total mass removed through vapor and was combined with the measured mass of recovered LNAPL to provide the total mass removed." Please revise Section 2.2.1 to provide information to support the correction factor methodology used and to document the PID readings before and after use of the correction factor.

3. **Section 2.2.1, SEE Mass Removal, Page 2-4:** Section 2.2.1 states, "The mass removed by SEE at ST012 suggests that the mass present pre-SEE could have been overestimated;" however, the basis for concluding that the mass present pre-SEE could have been overestimated is unclear. Given that SEE was not run until asymptotic conditions were achieved, please revise the Pilot Study WP to provide information to substantiate that the mass present pre-SEE could have been overestimated.

4. **Section 2.2.4, Temperature Data, Page 2-13:** The text states, "Temperatures are of interest to the EBR design for design selection, wastewater discharge limits, and potential biological activity;" however, a specific discussion regarding the temperature considerations related to potential biological activity [i.e., sulfate reducing bacteria (SRB)] is not presented and/or referenced. This is of particular concern given the elevated temperatures observed in some locations per Table 2-4 (TMP Temperature Readings for January 2018). Please revise the Pilot Study WP to include a specific discussion regarding the temperature considerations related to potential biological activity.

5. **Table 2-4, TMP Temperature Readings for January 2018, Page 2-14:** The geology associated with the TMP temperature reading provided in Table 2-4 is not provided and/or referenced. As such, it is unclear if the temperature reading is associated with specific subsurface conditions which may impact the EBR design. Please revise the Pilot Study WP to include cross-sections showing the geology associated with each TMP measurement depth.

6. **Section 2.3, Pre-EBR COC Extent Estimate, Page 2-17:** Calculation of estimated pre-EBR contaminant mass using literature residual saturation values was conducted; however, references for the literature residual saturation values are not provided. Further, adjusted and unadjusted calculations are not provided in the Pilot Study WP to support the use of literature residual saturation values as the best overall representation of site conditions. According to Section 2.3, "LNAPL removal percentages for this calibration step were adjusted to 80% in the TTZs (down from 90%), to 60% in the TIZ (no change from initial estimate) to 35% in the ROI (up from 30%), and to 26% in the LPZ (down from 30%). To account for a reduction in the volatile content of the remaining LNAPL due to the increased temperatures in the zones as demonstrated at other thermal sites, further reductions in BTEX+N mass were applied in both the TTZ (90%) and TIZ (25%) to estimate the quantity of BTEX+N remaining after SEE treatment." Please revise Section 2.3 to include references for the literature residual saturation values utilized and changes made to the removal percentages. In addition, please revise the Pilot Study WP to include both adjusted and unadjusted calculations to ensure the most conservative representation of site conditions is utilized.

7. **Section 2.3, Pre-EBR COC Extent Estimate, Page 2-18:** Section 2.3 states, "Although no direct treatment of the LPZ is planned, the sulfate injection in the UWBZ above and the LSZ [Lower Saturation Zone] below is expected to contribute to biological treatment in this zone;" however, information to substantiate that sulfate injection in the UWBZ

above and the LSZ below the LPZ will potentially contribute to biological treatment in the LPZ is not provided and/or referenced. Please revise Section 2.3 to provide information to substantiate that the sulfate injection in the UWBZ above and the LSZ below the LPZ will potentially contribute to biological treatment in the LPZ. In addition, please ensure that sufficient monitoring of the LPZ is conducted to show that the sulfate injection in the UWBZ above and the LSZ below the LPZ contributed to biological treatment in the LPZ.

8. **Section 2.6, Groundwater Model Sulfate Distribution Tracking, Page 2-20 and Table 2-8, Summary of Updated Model Layers, Page 2-23:** Section 2.6 states, "A 3D groundwater model was used for the original RD/RAWP [remedial design/remedial action work plan]. For design consistency, the same model was used with some parameter updates;" however, the specific parameter updates are not provided and/or referenced. Similarly, Table 2-8 presents a summary of updated model layers but does not discuss the updates made. Please revise the Pilot Study WP to provide a comparison table highlighting information from the initial and the updated groundwater model for transparency.

9. **Table 2-7, Background Sampling by Sampling Date and ID, Pages 2-21 to 2-22:** Footnote 1 indicates that the background data collected in September 2015 and reported in Table 2-7 has not been validated and is considered preliminary; however, this data should have been validated by the time of the Pilot Study WP issuance. Please revise Table 2-7 and all other tables within the Pilot Study WP to present validated data.

10. **Section 3.1.2, Sulfate, Page 3-2:** Section 3.1.2 states, "ST012 also has a naturally occurring supply of sulfate replenished by upgradient groundwater, which will serve to continue treatment after active remediation has ended;" however, insufficient information is provided to support this statement. While Table 2.7 (Background Sampling by Sampling Date and ID) does include some background sulfate data, without the groundwater flow direction, the significance of this data is unclear. Please revise the Pilot Study WP to provide sulfate data from upgradient groundwater to substantiate that ST012 has a naturally occurring supply of sulfate that is replenished by upgradient groundwater, which will serve to continue treatment after active remediation has ended.

11. **Section 3.1.3, TEA Selection, Page 3-3:** Section 3.1.3 states, "influent upgradient background sulfate can supplement sulfate amendments to promote petroleum hydrocarbon degradation during and after EBR without having to change the established bacterial populations or redox conditions;" however, influent information to support this statement is not provided and/or referenced in the Pilot Study WP. While Table 2.7 (Background Sampling by Sampling Date and ID) does include some background sulfate data, without the groundwater flow direction, the significance of this data is unclear. Please revise the Pilot Study WP to include information to substantiate that influent upgradient background sulfate can supplement sulfate amendments to promote petroleum hydrocarbon degradation during and after EBR without having to change the established bacterial populations or redox conditions.

12. **Section 3.2.1, Groundwater Extraction and Treatment, Page 3-3:** Section 3.2.1 indicates that groundwater will be extracted from 20 extraction wells; however, the text does not indicate why 20 extraction wells are sufficient for the EBR design. Please revise Section 3.2.1 to clarify why 20 extraction wells are sufficient for the EBR design.

13. **Section 3.2.2, Phased TEA Batch Injections, Page 3-5:** Section 3.2.2 indicates that batch TEA injections will be performed in discrete phases separated by monitoring periods; however, the duration of the monitoring periods is not specified nor is the basis for the duration to be utilized included. As such, it is unclear how the monitoring periods were specified. Please revise Section 3.2.2 to specify the duration of the monitoring periods and provide information supporting the timeframe to be utilized.

14. **Section 3.2.2, Phased TEA Batch Injections, Pages 3-4 to 3-6:** Section 3.2.2 assumes that using sequenced extraction with discrete injection will adequately distribute TEA in the subsurface; however, this assumption is based on a groundwater model that previously did not include any site-specific hydraulic parameters for the CZ. Given that updated groundwater model input parameters have not been provided in the Pilot Study WP, it remains unclear if the groundwater model included site-specific hydraulic parameters for the CZ which would support the assumption that phased discrete injections will result in subsurface TEA distribution. Please revise the Pilot Study WP to include the updated groundwater model input parameters. In addition, please ensure site-specific hydraulic parameters for the CZ are utilized to support the assumption that this technique will provide subsurface TEA distribution or discuss the uncertainty if literature values for the CZ were used in the model.

15. **Section 3.3, TEA Dosage, Page 3-7:** The text states, "Although BTEX+N are the primary COCs, indigenous microbes will consume sulfate while degrading non-targeted compounds;" however, information to support this statement is not provided and/or referenced. This is of particular concern given the lack of microbial information following SEE. Please revise Section 3.3 to provide information to substantiate that sufficient indigenous microbes are present following SEE to consume sulfate while degrading non-targeted compounds.

16. **Section 3.3, TEA Dosage, Page 3-7:** Section 3.3 states, "Individual areas of well influence were determined using Theissen polygons fitted to the injection locations in each vertical layer adjusted by observed groundwater flow contours at the site;" however, figures showing the Theissen polygons fitted to the injection locations in each vertical layer adjusted by observed groundwater flow contours at the site are not provided and/or referenced. Please revise the Pilot Study WP to provide figures showing the Theissen polygons fitted to the injection locations in each vertical layer.

17. **Section 3.3, TEA Dosage, Page 3-8:** Section 3.3 includes a summary of analyses of sodium sulfate for arsenic conducted between July 2016 and April 2017, which indicate that arsenic was non-detect; however, arsenic concentrations may be different in current sodium sulfate batches. Please revise the Pilot Study WP to provide current arsenic data

to substantiate that arsenic is not present in the sodium sulfate that will be used for TEA injections.

18. **Section 4.1.1, Post-SEE TEA Injection System Construction, Page 4-1:** The text indicates that several TEA injection locations cannot be reached by temporary piping/hoses and will require remote injections from a mobile injection tank; however, the TEA injection locations which cannot be reached by temporary piping/hoses are not specified or referenced on a figure. Please revise Section 4.1.1 to specify the TEA injection locations which cannot be reached by temporary piping/hoses. In addition, please revise the Pilot Study WP to include a figure showing the TEA injection locations which cannot be reached by temporary piping/hoses.

19. **Section 4.1.3, Installation of Groundwater Extraction Treatment Equipment, Page 4-5:** Section 4.1.3 states, "All reused equipment was evaluated for effective use at the expected groundwater flow rate;" however, documentation of these evaluations is not provided and/or referenced. Please revise Section 4.1.3 to provide and/or reference documentation of the evaluation of reused equipment for effective use at the expected groundwater flow rates.

20. **Section 4.2.2, TEA Dosing, Pages 4-6 to 4-7:** Section 4.2.2 indicates that batch testing of the TEA solution at a target concentration of approximately 160 grams per liter (g/L) was prepared to evaluate potential inhibitory effects of high TEA injection solution concentrations; however, documentation of the batch testing is not provided and/or referenced. Please revise Section 4.2.2 to provide and/or reference documentation of the batch testing conducted to evaluate potential inhibitory effects of high TEA injection solution concentrations.

21. **Section 4.2.2, TEA Dosing, Page 4-7:** Section 4.2.2 indicates that bulk bags of sodium sulfate will be emptied into 18,000 gallon open-top frac tanks using a reach forklift and will be mixed by recirculation using a double diaphragm pump prior to injection to ensure solution uniformity; however, it is unclear if the double diaphragm pump will be sufficient to uniformly mix the solution in the frac tanks. Please revise the Pilot Study WP to include additional measures to ensure the solution in the frac tanks is uniformly mixed.

22. **Section 4.2.6, Conceptual EBR Contingency Planning, Page 4-12:** The Limited Sulfate Distribution subsection indicates that in areas of insufficient TEA distribution, additional injection/extraction wells or injection/extraction from different existing wells will be considered; however, it is unclear how insufficient TEA distribution will be determined given the lack of groundwater monitoring in the vicinity of the injection/extraction well pairs. Similarly, the Limited Sulfate Distribution subsection indicates that if it appears that travel times and dispersion are slower than expected, conversion to a recirculation system with additional injection and extraction locations will be considered; however, it is unclear how it will be known if dispersion is slower than expected if the sulfate never arrives at an extraction well and a tracer is not used. Please revise Section 4.2.6 to clarify how insufficient TEA distribution will be

determined given the lack of groundwater monitoring wells in the vicinity of the injection/extraction wells. In addition, please clarify how it will be known if dispersion is slower than expected if the sulfate never arrives at an extraction well or revise the Pilot Study WP to require use of one or more tracers.

23. **Section 4.2.6, Conceptual EBR Contingency Planning, Page 4-13:** The Limited VOC Reduction subsection assumes that SRB populations are active; however, without sampling, information to support this statement is not provided. It is unclear if the proposed qPCR analyses that will be conducted for samples collected from two wells per zone will be sufficient to evaluate whether sufficient SRB are present, particularly in the CZ that was recently saturated. Please revise the Pilot Study WP to include sufficient sampling for SRB populations to support this statement.

24. **Section 4.2.6, Conceptual EBR Contingency Planning, Page 4-14:** The text indicates that injection and/or extractions wells will be redeveloped by mechanical removal and/or chemical addition (e.g., biocide) to restore well function yet the specific biocide that could potentially be used is not specified. As a result, it is unclear if this chemical addition product will impact the SRB population. Please revise the Pilot Study WP to specify the chemical addition products that will be utilize and provide information to substantiate that the chemical addition will not impact the SRB populations that are critical to the EBR design. Alternatively, please revise the Pilot Study WP to include baseline and post-chemical addition SRB population sampling to ensure the chemical additive is not impacting the SRB populations.

25. **Table 5-1, EBR Monitoring, Sampling, and Analysis Methods and Frequencies, Page 5-2:** The Re-Baseline sampling event proposed in Table 5-1 does not include alkalinity or sulfate sampling which was previously conducted during the baseline sampling. It should be noted that the baseline sampling for alkalinity is included in Table 5-1 but not in Section 5.1.1 [Pre-EBR Groundwater Sampling (Completed in 2016)]. However, sulfate is listed as an analysis to be conducted during the Re-Baseline sampling event. Please revise the Pilot Study WP to ensure the Re-Baseline sampling event includes alkalinity and sulfate sampling. In addition, please revise Table 5-1 and Section 5.1.1 to resolve the discrepancy regarding alkalinity testing during baseline sampling.

26. **Section 5.4, Groundwater Monitoring Well Sampling, Page 5-12:** Section 5.4 states, "Bio-trap® samplers from Microbial Insights, seeded with synthesized forms of benzene and naphthalene containing carbon isotope ^{13}C, will be placed in each well for approximately one month;" however, the decision criteria used to determine the location of the Bio-trap® samplers within each well is not provided and/or referenced. Please revise Section 5.4 to include the decision criteria used to determine the location of the Bio-trap® samplers within each well.

27. **Figures 2-4 (Removal Contours, CZ 155 feet below ground surface), 2-5 (Removal Contours, UWBZ 175 feet below ground surface), and 2-6 (Removal Contours, LSZ 215 feet below ground surface):** Information to support the extents of the TTZ, TIZ, and Radius of Influence (ROI) on Figures 2-4, 2-5, and 2-6 are not provided. According

to Section 2.3 (Pre-EBR COC Extent Estimate), Figures 2-4, 2-5, and 2-6 visually illustrate the application of the different percentage removals for the TTZ, TIZ, and the ROI in typical depth intervals for the CZ, UWBZ, and LSZ, respectively. In addition, the removal percentages applied to each zone are not shown on the figures. Please revise the Pilot Study WP to provide information to support the extents of the TTZ, TIZ, and ROI for the CZ, UWBZ, and LSZ. In addition, please revise the figures to include the removal percentages applied to each zone.

28. **Figure 3-1, EBR System Process Flow Diagram:** Figure 3-1 indicates that LNAPL will be separated into its own tank following the oil water separator; however, it is unclear how the LNAPL will be managed after containment in the LNAPL tank. Please revise the Pilot Study WP to clarify how the LNAPL will be managed after containment in the LNAPL tank.

29. **Appendix A, 2017 Mass Update Calculations:** Based on Appendix A, the same grain density is utilized for each aquifer in the Pre-SEE mass, Post-SEE mass and Additional Characterization Update calculations; however, information to support the use of the same grain density for each aquifer, presumably an average grain density, is not provided and/or referenced. Please revise the Pilot Study WP to utilize aquifer-specific average grain densities or provide and/or reference information to substantiate the use of the same grain density for each aquifer.

30. **Appendix B, Estimated LNAPL Extent Figures:** Appendix B includes figures showing the estimated LNAPL extent; however, information to support the delineated extent of residual LNAPL is not provided and/or referenced. For example, areas defined as the delineated extent of residual LNAPL are not bound by any boring or monitoring locations shown on the figures. As such, it is unclear how the estimated LNAPL extents were developed. Please revise the Pilot Study WP to provide information to support the delineated extent of residual LNAPL presented in Appendix B.

31. **Appendix F, Groundwater Model Outputs, Figure F-2, Conservative Tracer Transport Model Results, Cobble Zone – 160 ft bgs, Initial Conditions (Day 0):** Figure F-2 of Appendix F includes an area with a blue sulfate concentration above background units in the southern portion of the ST012 site near ST012-UWBZ33. This is of particular note given that no CZ monitoring well is located near this location. Please revise the Pilot Study WP to clarify why this blue sulfate concentration above background units exists.

32. **Appendix G, TEA Injection Well Distribution Calculations, Sheet 1 of 5:** Text within Calculation 1 of Appendix G is cutoff. Please revise Appendix G to ensure all text is readable.

33. **Appendix G, TEA Injection Well Distribution Calculations, Sheet 1 of 5:** Several Untreated cells within the Calculation 1 table state "Area_SqFt" without explanation. Please revise Appendix G to ensure the abbreviations, acronyms, and placeholders are clearly defined or provide the missing data entries.

34. **Appendix I, QAPP/SAP Worksheets:** The QAPP indicates that it was prepared in accordance with the requirements of Version 4.2 of the Department of Defense Quality Systems Manual (DoD QSM), but a newer version is available (Version 5.1, dated January 2017). Please revise the QAPP to clarify why the older version of the DoD QSM is referenced, or revise the QAPP to use the newer version.

35. **Appendix I, QAPP/SAP Worksheets:** The QAPP references the Program QAPP for document control procedures. The Program QAPP briefly discusses document control procedures but does not provide sufficient detail regarding the management of the project files. The QAPP should indicate where the project files will be stored (i.e., provide the address), who will manage them, and the minimum length of time the files will be kept. The QAPP should also indicate that records will be offered to EPA prior to disposal. Please revise the QAPP to provide this information.

36. **Appendix I, QAPP/SAP Worksheets:** The QAPP references the Program QAPP for data validation procedures, but the procedures described in the Program QAPP are insufficiently detailed. For example, Worksheet #36 in the Program QAPP indicates that data validation will be performed in accordance with the analytical methods, laboratory SOPs, DoD QSM, and the EPA National Functional Guidelines (NFGs) for Organic and Inorganic Data Review. However, since multiple sources will be used for data validation procedures, a data validation checklist describing how samples will be qualified (e.g., the qualifiers that will be used, when samples will be qualified as estimated/rejected, and if individual or all samples in a batch will be qualified) should be provided. As a second example, the Program QAPP does not indicate what will be included in the data validation reports. Please revise the QAPP to provide a data validation checklist. Please also revise the QAPP to ensure that data validation reports will present a discussion of all quality control (QC) parameters evaluated, the acceptance criteria used to evaluate each QC parameter, a list of all QC exceedances as well as the extent of the exceedance, the samples associated with each exceedance, and the qualifiers applied.

37. **Appendix I, QAPP/SAP Worksheets:** The QAPP does not discuss manual integrations for chromatographic analyses. Please revise the QAPP to ensure that if manual integration is required, the supporting information (i.e., chromatograms before and after manual integration as well as a brief explanation for needing the manual integration) will be included in the data package deliverables and evaluated during data validation.

38. **Appendix I, QAPP/SAP Worksheets, UFP-QAPP Crosswalk:** The UFP-QAPP Crosswalk to Related Information indicates that QAPP Worksheet #13 is included in the Pilot Study Work Plan; however, this worksheet is not provided. Please revise the QAPP to include Worksheet #13 or to specify where the information can be found.

39. **Appendix I, QAPP/SAP Worksheets, UFP-QAPP Crosswalk:** The QAPP Crosswalk to Related Information indicates that QAPP Worksheet #13 is included in the Pilot Study Work Plan; however, this worksheet is not provided. Please revise the QAPP to include Worksheet #13 or to specify where the information can be found.

40. **Appendix I, QAPP/SAP Worksheets, QAPP Worksheet #5, Project Organizational Chart, Page 2:** The organization chart shows a partial line of authority and no lines of communication for the Amec Foster Wheeler quality assurance (QA) Lead. Please revise the organization chart to show that the QA role is independent of all other project tasks as indicated by lines of communication and not lines of authority.

41. **Appendix I, QAPP/SAP Worksheets, QAPP Worksheet #6, Communication Pathways, Pages 1 to 3:** The communication procedures do not always specify the form of communication for the notifications (e.g., via email). Please revise the table to include the form of communication for all communication drivers, as well as the necessary contact information (i.e., email addresses, phone numbers, etc.).

42. **Appendix I, QAPP/SAP Worksheets, QAPP Worksheet #11, Project Quality Objectives/Systematic Planning Process Statements, Page 2:** Step 3, Decision Inputs, includes a list of worksheets where specific information can be found; however, several of the worksheets listed are not provided in the QAPP (QAPP Worksheets #27, #29, #34-37). Please revise this worksheet to specify where project documentation, data management, verification and validation criteria, and data usability requirements can be found. Alternatively, please revise the QAPP to include QAPP Worksheets #27, #29, and #34-37.

43. **Appendix I, QAPP/SAP Worksheets, QAPP Worksheet #11, Project Quality Objectives/Systematic Planning Process Statements, Pages 1 to 3**: The information in this worksheet is insufficiently detailed. For example, the analytic approach should provide decision statements (i.e., "if…, then,,," statements) for how the project data will be used. As a second example, the screening levels that will be used for making each project decision have not been defined. As a third example, Step 6 should examine consequences of making incorrect decisions from the test, and place acceptable limits on the likelihood of making decision errors. Please revise QAPP Worksheet #11 to provide additional detail following EPA's Guidance on Systematic Planning Using the Data Quality Objectives Process (QA/G-4).

44. **Appendix I, QAPP/SAP Worksheets, QAPP Worksheet #12, Measurement Performance Criteria, Pages 1 to 3:** The numerical measurement performance criteria (MPC) have not been specified. For example, the MPC for precision is defined as "RPD [relative percent difference] of MS/MSD [matrix spike/matrix spike duplicate]," but the numerical criteria that will be used to assess precision (e.g., <25%) have not been specified. Normally, QAPP Worksheet #12 is broken down into separate tables for each analysis (e.g., one table for 6010, one table for 8270, etc.). Please revise QAPP Worksheet #12 to include the quantitative MPC for each data quality indicator (DQI), and split up the tables by analyses.

45. **Appendix I, QAPP/SAP Worksheets, QAPP Worksheet #15, Reference Limits and Evaluation, Pages 1 to 6**: This worksheet provides target reporting limits (RLs) and approximate method detection limits (MDLs) for the analyses to be performed by

TestAmerica. However, the laboratory-specific RLs and MDLs should be provided in the QAPP to ensure PALs can be met. Additionally, the PAL for several analytes is listed as "NA" [not applicable], and therefore, it is unclear how these results will be evaluated. Please revise the QAPP to provide the laboratory-specific RLs and MDLs, and to discuss how results with no PAL will be evaluated.

46. **Appendix I, QAPP/SAP Worksheets, QAPP Worksheet #18, Sampling Locations and Methods/SOP Requirements Table, Page 34:** QAPP Worksheet #20 indicates that field duplicate samples are to be collected at a rate of 5%. However, the locations of field duplicate samples have not been identified in Table 18.10 (Microbial Monitoring Well Sampling) for microbial monitoring well sampling. Please revise the QAPP to identify the sample locations of field duplicate samples for all analytical methods.

47. **Appendix I, QAPP/SAP Worksheets, QAPP Worksheet #21, Project Sampling SOP References Table, Page 1:** This worksheet presents an incomplete list of the project sampling SOPs required for this investigation. For example, Tables 18.7 (Biweekly to Monthly Extraction Well Sampling) and 18.8 (Weekly to Monthly Extraction Well Sampling) in Worksheet #18 indicate that extraction well sampling includes sulfate field screening; however, the QAPP does not include procedures for sulfate field screening. Please ensure that all field sampling procedures are provided in the QAPP.

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May 17, 2018

Ms. Carolyn d'Almeida
Remedial Project Manager
Federal Facilities Branch (SFD 8-1)
US EPA Region 9 Laboratory
1337 South 46th Street, Building 201
Richmond, CA 94804

Subject: Contract No. EP-W-07-066, Task Order No 066-016-09Q1, Williams Air Force Base Task Order, Review of Appendices F and H of the Resubmitted Final Pilot Study Implementation Work Plan for Operable Unit 2, Revised Groundwater Remedy, Site ST012, Former Williams Air Force Base, Mesa, Arizona, April 2018

Dear Ms. d'Almeida:

TechLaw conducted a technical review of Appendices F and H of the Resubmitted Final Pilot Study Implementation Work Plan for Operable Unit 2, Revised Groundwater Remedy, Site ST012, Former Williams Air Force Base, Mesa, Arizona (the Pilot Study WP), dated April 5, 2018.

The comments are forwarded to you in Word format. TechLaw understands you will review and revise these comments at your discretion.

We appreciate the opportunity to provide technical support services to U.S. EPA on this Task Order. Should you have any questions or comments, please contact me or the TechLaw Project Manager, Nicole Goers, at (540) 836-0420.
Sincerely,

Indira Balkissoon
ROC 9 Senior Task Order Manager

KB:NG:IB:as

cc: Central files, TechLaw, Inc.

FORMER WILLIAMS AIR FORCE BASE
Mesa, Arizona

Review of Appendices F and H of the Resubmitted Final Pilot Study Implementation Work Plan for Operable Unit 2, Revised Groundwater Remedy, Site ST012, April 2018

Submitted to:

Ms. Carolyn d'Almeida
Remedial Project Manager
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Submitted by:

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Task Order No.	**066-016-09Q1**
Contract No.	**EP-W-07-066**
EPA TOCOR	**Carolyn d'Almeida**
Telephone No.	**(415) 972-3150**
TechLaw TO Manager	**Nicole Goers**
Telephone No.	**(540) 836-0420**

May 17, 2018

Review of Appendices F and H of the Resubmitted Final Pilot Study Implementation Work Plan for Operable Unit 2, Revised Groundwater Remedy, Site ST012, April 2018

GENERAL COMMENTS

1. Actual water level measurement data should be collected for comparison with the Groundwater Head Model Results figures in Appendix F (Figures F-31 through F-60) to validate the groundwater model. This will facilitate evaluation of the degree to which the groundwater model represents actual conditions and to track the progress of remediation. These water level measurements should be collected at the same intervals as the model figures (i.e., at 30 days, 120 days, and 7, 10, 15, 20, 25, 40, and 72 months). Figures comparing the actual and modeled heads should be provided to the Regulatory Agencies within 30 days after water level measurements to facilitate discussions about the progress of the Pilot Study and the effectiveness of the groundwater model for evaluating the Pilot Study. Please ensure that water level measurements are collected and figures comparing the actual and modeled heads are provided to the Regulatory Agencies on a regular basis.

2. The basis for some of the changes made to the groundwater model is unclear. For example, it is unclear why the modeled time periods changed. This change made it difficult to compare the previous model figures with the recently revised model figures to understand the impact of changes in sulfate injection concentrations. Similarly, the locations of some injection and extraction wells were changed, but there is no explanation for this change. Please revise the text to explain the basis for all changes to the groundwater model.

SPECIFIC COMMENT

1. **Section 3.2.2, Phased TEA Batch Injections, Page 3-6 and Appendix F, Groundwater Model Outputs, Design Flow Rate Sheet, PDF Page 184:** The text in Section 3.2.2 states, "In general, extraction wells were run continuously in the model until completion of the Phase 1 injections (about 330 days), with the exception of five extraction wells (ST012-CZ07, ST012-CZ18, ST012-CZ19, ST012-CZ21, and ST012-UWBZ28)," but the table in the Appendix F Constants and Inputs subsection on pdf page 184 indicates that all of the wells ran for a period of time and were cycled off after each Phase I injection period. Please resolve this discrepancy.